Detailed modelling of the HERA antenna response due to variations in feed positions

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ABSTRACT

The spectrally-smooth foreground synchrotron emission is at least 3-5 orders of magnitude brighter than the predicted redshifted neutral hydrogen 21-cm signal from the Epoch of Reionization (EoR). In the cylindrically averaged k-space power spectrum, it is crucial to minimize contamination in the EoR Window due to signal leakage outside the foreground 'wedge'. Unwanted variations in antenna beam patterns between the interferometer elements can contribute to such leakage. We present a framework for characterizing the unwanted antenna beam variations due to changes in feed positions in the Hydrogen Epoch of Reionization Array (HERA). Using the commercial computational electromagnetic (CEM) software, CST, we have simulated the antenna response for a single HERA dish-feed element as a function of feed offset relative to its nominal position over frequencies of interest. We present results and characterize the beam responses at different feed positions. Simulation self-consistency is assessed by using different CEM solver methods. The CST results are cross-checked with the field-measured antenna reflection coefficients on an early HERA prototype element. This analysis highlights the need for ground-truth measurement of the antenna performance.

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